Rapid High Adsorption Performance of Hydrous Cerium-Magnesium Oxides for Removal of Fluoride from Water

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Abstract

A simple co-precipitation method was used to prepare a series of eco-friendly hydrous cerium-magnesium bimetal oxides (HCeMgO1:2, HCeMgO1:3, HCeMgO1:1 and HCeMgO2:1) adsorbents at different Ce/Mg molar ratio for fluoride removal from aqueous solution. The ideal adsorbent, HCeMgO1:1, not only demonstrated high adsorption efficiency but also rapid kinetics. Comprehensive characterization of HCeMgO1:1 before and after fluoride adsorption was performed using Scanning Electron Microscope (SEM), High Resolution Transmission Electron Microscope (HR-TEM), X-ray Photoelectron Spectroscopy (XPS), Fourier Transform Infrared Spectroscopy (FTIR), point-of-zero charge, Thermogravimetric-Differential Thermal Analysis (TG-DTA), Brunauer-Emmett-Teller (BET) and X-ray Diffraction (XRD) techniques. The BET surface area of HCeMgO1:1 was around 34.06 m^2/g. The effect of various parameters such as adsorbent dosage, contact time, initial concentration, initial pH and co-existing ions was investigated in batch mode. Desorption study was explored to test the reusability of HCeMgO1:1. A pseudo-second-order model described the adsorption kinetics best with 5–20 minute rapid equilibrium adsorption. Fluoride uptake followed Langmuir model, with maximum adsorption capacities in the range of 66.23–80.00 mg/g from 25 to 45 °C at pH value 5.5. Both ion exchange and electrostatic interactions were found to dictate the process. The sorption was spontaneous and endothermic in nature. The revival study of the fluoride laden HCeMgO1:1 exhibited a high desorption efficiency up to four adsorption-desorption cycles. Further assay on underground water samples deep-rooted the potential use of HCeMgO1:1 as suitable candidate for defluoridation.

Keywords: adsorption, hydrous, Fluoride, efficiency, Initial